CONTROLLED FAN STREAM FLOW BYPASS

BACKGROUND

[0001] The invention relates to high bypass turbofan engines and, more particularly, relates to controlled fan stream flow bypass for high bypass turbofan engines.

[0002] Current practice for high bypass ratio turbofan engines is to utilize fixed area exhaust nozzles for both the fan duct stream and the turbine exhaust stream. As lower fan pressure ratios are utilized to achieve improved propulsive efficiency and reduced noise levels, the mis-match between fan operation at cruise conditions and operation at take-off conditions increases. This mis-match can be addressed using conventional approaches, but with a significant increase in weight, cost and complexity.

[0003] This mis-match can be explained with respect to the aero-thermodynamics involved within the high bypass ratio turbofan engine. FIG. **1** illustrates the change in fan duct stream nozzle flow capacity when going from operation at a cruise Mach Number of 0.85 to static conditions experienced during take-off operation for an engine with a fan pressure ratio of 1.6 at cruise conditions. FIG. **2** illustrates the change in fan operation for static conditions that results from this change in nozzle flow capacity. This change in flow capacity and resulting change in fan operation is the result of losing the benefit of ram pressure ratio due to aircraft flight Mach Number at static conditions. The change in fan operation shown for this example is typical of many operational engines and results in an acceptable loss in fan stall margin and fan flutter margin. Fan flutter margin is the margin of fan pressure ratio between fan operation and the limits where aeromechanical instability occurs. Fan stall margin is the margin of fan pressure ratio between fan operation and the limits where aerodynamic instability occurs.

[0004] As the fan pressure ratio at cruise is reduced, ram pressure ratio makes up a much larger fraction of the nozzle pressure ratio, and operation at static conditions results in a much larger change in both nozzle flow capacity and fan operation. FIG. **3** illustrates the change in fan duct stream nozzle flow capacity when going from operation at a cruise Mach Number of 0.85 to static conditions experienced during take-off operation for an engine with a fan pressure ratio of 1.3 at cruise conditions. FIG. **4** illustrates the change in fan operation for static conditions that results from this change in nozzle flow capacity. The change in fan operation shown in this example is that which might be expected for future very high bypass ratio engines, and results in an unacceptable loss in fan stall margin and fan flutter margin. FIG. **5** illustrates how an increase in fan duct stream nozzle area can be used to restore fan operation with acceptable fan stall margin and fan flutter margin. However, as mentioned above, achieving an increase in fan duct stream nozzle area at static conditions using conventional approaches results in significant increases in cost, weight, and complexity.

[0005] Therefore, there exists a need to achieve the benefit of varying the fan duct stream area while minimizing the impact of weight, cost and complexity.

SUMMARY

[0006] In one aspect of the present disclosure, a turbine engine component of a turbofan engine fitted with a bypass air valve broadly comprises at least one turbine engine component having a surface with at least one aperture, the turbine engine component located from between a bypass fan duct and a turbine exhaust nozzle of the turbofan engine; a bypass air valve broadly comprising a liner concentrically disposed about the turbine engine component and parallel to a centerline of the turbofan engine, said liner having a surface including at least one aperture and at least one impermeable region, and means for actuating the liner about the turbine engine component; and a flow transfer location comprising an area proximate to a turbine exhaust stream flow.

[0007] In another aspect of the present disclosure, a process for controlling fan stream flow bypass of a turbofan engine broadly comprises providing a turbine engine component having a surface including at least one aperture, and located from between a bypass fan duct and a turbine exhaust nozzle of the turbofan engine; providing a bypass air valve having a surface including at least one aperture and at least one impermeable region, and concentrically disposed about the turbine engine component and parallel to a centerline of the turbofan engine; introducing a fan exhaust stream flow into the turbofan engine; actuating the bypass air valve to substantially align at least one aperture of the bypass air valve with at least one aperture of the turbine engine component; and permitting flow transfer by substantially aligning at least one apertures and transferring the fan exhaust stream flow into a turbine exhaust stream flow of the turbofan engine at a flow transfer location.

[0008] The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** illustrates a change in fan duct stream nozzle flow capacity from a cruise Mach Number of 0.85 to static conditions experienced during take-off operation for a single stage, high bypass ratio turbofan engine with a fan pressure ratio of 1.6 at cruise conditions;

[0010] FIG. **2** illustrates the change in fan operation of the engine at static conditions that results from a change in nozzle flow capacity as illustrated in FIG. **1**;

[0011] FIG. **3** illustrates a change in fan duct stream nozzle flow capacity from a cruise Mach Number of 0.85 to static conditions experienced during take-off operation for a single stage, high bypass ratio turbofan engine with a fan pressure ratio of 1.3 at cruise conditions;

[0012] FIG. **4** illustrates a change in fan operation of the engine for static conditions that results from the change in nozzle flow capacity as illustrated in FIG. **3**;

[0013] FIG. **5** illustrates how an increase in fan duct stream nozzle area can be used to achieve fan operation with acceptable fan stall margin and fan flutter margin;

[0014] FIG. **6** is a representation of a liner of the bypass air valve of the present disclosure in a spatial relationship to a surface separating the fan duct stream flow from the turbine exhaust stream flow;

[0015] FIG. **7**A is a representation of a cross-sectional view of an upper half of a single stage, high bypass ratio turbofan engine equipped with an exemplary embodiment of a bypass air valve of the present disclosure;

[0016] FIG. **7**B is a representation of the turbofan engine of FIG. **7**A equipped with another exemplary embodiment of a bypass air valve of the present disclosure;